β

Name Key
(Please print family name last; e.g., Robert Boyle)

Student Number _____

Chem 116 - Section 1
Hour Examination I
March 9, 2007

This test consists of five (5) pages, including this cover page. Be sure your copy is complete before beginning your work. If this test packet is defective, ask for another one. A separate copy of the periodic table will be distributed with this test.

☛ **You must show work in the spaces provided that leads to your answers to problems 2 and 3. Answers without such work receive no credit.**

Ideal Gas Law Constant = R = 0.08206 L·atm/K·mol = 8.314 J/K·mol
Molar volume of an ideal gas at STP = 22.4 L/mol
K = °C + 273.15 1.00 atm = 760 mm Hg $N_A = 6.022 \times 10^{23}$

DO NOT WRITE BELOW THIS LINE

1.

2.

3.

TOTAL

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1. (68 points; 4 points each) Circle the best answer to each of the following.

a. "The total pressure of a mixture of gases equals the sum of the pressures that each would exert if it were present alone" is a statement of the relationship discovered by

Amonton Avogadro Boyle Charles (Dalton)

b. How high in meters must a column of glycerine be to exert a pressure equal to that of a column of mercury 772 mm high? The density of mercury is 13.6 g/mL, and that of glycerine is 1.26 g/mL.

0.0715 m 0.772 m 0.973 m (8.33 m) 10.5 m

c. A gas sample is contained in a 3.00-L vessel at 63 °C and 6.00 atm. What is the pressure if the temperature is increased to 175 °C?

2.16 atm 4.55 atm 6.00 atm (8.00 atm) 16.7 atm

d. A sample of gas in a steel tank with a volume of 927 mL at 15 °C has a pressure of 1250 torr. How many moles of gas does the tank contain?

0.0505 mol 15.5 mol 1.24 mol 0.807 mol (0.0645 mol)

e. Consider one mole samples of each of the following gasses under the conditions specified. Which one has the lowest root-mean-squared velocity?

$CO_2(g)$ at 300 K He(g) at 300 K ($SF_6(g)$ at 300 K)

$F_2(g)$ at 400 K $H_2(g)$ at STP

f. A 0.132-mol sample of He(g) (at. wt. 4.00 u) effuses from a certain apparatus in 15.0 s. How many moles of O_2 (m.w. 32.0 u) would effuse in the same time from the same apparatus under identical conditions?

0.0165 mol (0.0467 mol) 0.132 mol 0.373 mol 1.06 mol

g. Which one of the following is most volatile?

CBr_4 (CH_3Cl) $CHCl_3$ CH_2Cl_2 CCl_4

h Which one of the following is capable of hydrogen bonding between its molecules?

($HOCH_2CH_2OH$) CH_3OCH_3 $(CH_3)_3N$ H_2S CH_3F

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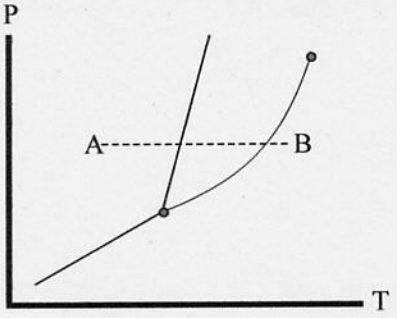
i. Consider the following phase diagram for a certain substance.



If the temperature is increased as indicated by the dotted line A-B, which of the following describes the sequence of phases that will be observed?

(solid → liquid → gas) gas → liquid → solid liquid → solid → gas

solid → gas → liquid gas → solid → liquid

j. A gas mixture contains 0.120 mol $N_2(g)$ and 0.360 mol $O_2(g)$ and has a total pressure of 1.64 atm. What is the partial pressure of $O_2(g)$ in the mixture?

0.197 atm 0.410 atm 0.590 atm (1.23 atm) 1.64 atm

k. Based on the nature of the solid, which of the following has the lowest melting point?

(C_6H_{12}) C_2H_5OH Cr SiO_2 MgO

l. Which one of the following gasses might be expected to show the most significant deviation from ideal-gas behavior at low temperature?

CH_4 (HF) H_2 CO_2 N_2

m. Which one of the following is probably most soluble in hexane, $C_6H_{12}(l)$?

($CH_3(CH_2)_{16}CO_2H$) NaCl H_2O CH_3OH CH_3CO_2H

n. Which one of the following would have the highest osmotic pressure at 25° C?

0.120 M glucose (0.075 M NaCl) 0.120 M CH_3CO_2H 0.035 M $CaCl_2$ 0.035 M Na_3PO_4

o. A temperature and pressure at which gas and solid phases are in equilibrium is a

triple point boiling point critical point (sublimation point) melting point

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p. For a 0.0100 *m* solution of $K_2SO_4(aq)$, the measured value of the van't Hoff *i* factor is 2.70. If this solution behaved ideally, what would the expected value of *i* be?

1.00 1.01 2.00 2.70 (3.00)

q. At 20 °C, the vapor pressure of pure benzene is 75 torr and that of toluene is 22 torr. If equal moles of benzene and toluene are mixed, which of the following statements would describe the composition of the *vapor* in equilibrium with this solution?

The mole faction of both benzene and toluene would be 0.50.

The mole fraction of toluene would be greater than 0.50.

(The mole fraction of benzene would be greater than 0.50.)

2. (12 points) The freezing point of a solution prepared by mixing 5.68 g of an unknown molecular compound with 50.0 g of carbon tetrachloride is –34.2 °C. The freezing point of pure carbon tetrachloride is –22.3 °C, and its freezing point depression constant, K_f, is 29.8 °C/*m*. Given these data, what is the molecular weight of the unknown solute?

$$\Delta T = (-34.2 + 22.3)^\circ C = 11.9^\circ C$$

$$m = \frac{\Delta T}{K_f} = \frac{11.9^\circ C}{29.8^\circ C/m} = 0.399\ m$$

$$m.w. = \left(\frac{5.68\ g\ X}{50.0\ g\ CCl_4}\right)\left(\frac{10^3\ g\ CCl_4}{0.399\ mol\ X}\right) = 285\ g/mol$$

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3. (26 points + 5 point bonus) Hexabromobenzene (C_6Br_6, m.w. = 551.52 u) is a non-volatile solid that dissolves without dissociating in chloroform ($CHCl_3$, m.w. = 119.38 u). Consider a solution prepared by dissolving 65.0 g of hexabromorobenzene in 134 g of chloroform.

a. (10 points) What is the molality of the solution?

$$m = \left(\frac{65.0\text{ g } C_6Br_6}{134\text{ g } CHCl_3}\right)\left(\frac{\text{mol } C_6Br_6}{551.52\text{ g } C_6Br_6}\right)\left(\frac{10^3\text{ g } CHCl_3}{\text{Kg } CHCl_3}\right) = 0.879_{52}\,m$$

$$= 0.880\,m$$

b. (10 points) What is the mole fraction of *chloroform* (not hexabromobenzene) in this solution?

$$\text{mol } C_6Br_6 = (65.0\text{ g } C_6Br_6)\left(\frac{\text{mol } C_6Br_6}{551.52\text{ g } C_6Br_6}\right) = 0.117_{86}\text{ mol}$$

$$\text{mol } CHCl_3 = (134\text{ g } CHCl_3)\left(\frac{\text{mol } CHCl_3}{119.38\text{ g } CHCl_3}\right) = 1.12\text{ mol}$$

$$\chi_{CHCl_3} = \frac{1.12}{1.12 + 0.118} = 0.904_7$$

c. (6 points) The vapor pressure of pure chloroform at 25°C is 172 torr. Assuming ideal behavior, what is the expected vapor pressure above the solution at 25°C?

$$P_{CHCl_3} = (0.904_7)(172\text{ torr}) = 155.6\text{ torr} = 156\text{ torr}$$

Extra Credit (5 points) At what temperature in °C will the solution boil? $K_b = 3.63\,°C/m$ for $CHCl_3$. The freezing point of pure $CHCl_3(l)$ is 61.2°C.

$$\Delta T = (0.880\,m)(3.63\,°C/m) = 3.19\,°C$$

$$T_b' = (61.2 + 3.19)\,°C = 64.39\,°C = 64.4\,°C$$

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3. (20 points + 5 point bonus) Hexabromobenzene (C_6Br_6, m.w. = 551.52 u) is a non-volatile solid that dissolves in chloroform ($CHCl_3$, m.w. = 119.38 u). Consider a solution prepared by mixing 65.0 g of hexabromorobenzene in 134 g of chloroform.

a. (6 points) What is the molality of the solution?

$$m = \left(\frac{65.0\text{ g } C_6Br_6}{134\text{ g } CHCl_3}\right)\left(\frac{\text{mol } C_6Br_6}{551.52\text{ g } C_6Br_6}\right)\left(\frac{10^3\text{ g } CHCl_3}{\text{Kg } CHCl_3}\right) = 0.880\,m$$

b. (9 points) What is the mole fraction of *chloroform* (not hexabromobenzene) in this solution?

$$\text{mol } C_6Br_6 = (65.0\text{ g } C_6Br_6)\left(\frac{\text{mol } C_6Br_6}{551.52\text{ g } C_6Br_6}\right) = 0.117_{86}\text{ mol}$$

$$\text{mol } CHCl_3 = (134\text{ g } CHCl_3)\left(\frac{\text{mol } CHCl_3}{119.38\text{ g } CHCl_3}\right) = 1.12\text{ mol}$$

$$\chi_{CHCl_3} = \frac{1.12}{1.12 + 0.118} = 0.905$$

c. (5 points) The vapor pressure of pure chloroform at 25°C is 172 torr. Assuming ideal behavior, what is the expected vapor pressure above the solution at 25°C?

$$P_{CHCl_3} = (0.905)(172\text{ torr}) = 156\text{ torr}$$

Extra Credit (5 points) At what temperature in °C will the solution boil? $K_b = 3.63$ °C/*m* for $CHCl_3$. The boiling point of pure $CHCl_3$ is 61.2°C.

$$\Delta T = (0.880\,°C)(3.63\,°C/m) = 3.19°C$$

$$T_b' = (61.2 + 3.19)°C = 64.39°C = 64.4°C$$